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Avulsion Fracture of the Calcaneal Tuberosity: Case Report and Literature Review

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Case Reports and Series

Avulsion Fracture of the Calcaneal Tuberosity: Case Report and Literature Review

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ABSTRACT

Avulsion fractures of the calcaneal tuberosity are rare extraarticular injuries of the calcaneus, with a peak incidence in elderly females. Predominantly seen in patients with poor bone quality, the commonly used lag screw fixation might not be strong enough even with bony fragments of sufficient size and could result in treatment failure. We present a case of a closed displaced avulsion fracture of the calcaneal tuberosity due to blunt trauma to the calf in a 74-year-old female. Open reduction and internal fixation with two 3.5-mm cannulated cortical screws with washers was performed, and anatomic reduction was achieved. Without further trauma, secondary displacement of the fracture occurred on day 3. Revision was performed with a single 3.5-mm cortical screw and transosseous fixation with 2 suture anchors, followed by partial weightbearing for 6 weeks. At 12 weeks postoperatively, the fracture had completely healed. Transosseous suture anchor fixation of an osteoporotic avulsion fracture of the calcaneal tuberosity seems to provide better and stronger fixation than that using lag screws.

Calcaneal fractures account for 1.2% to 2% of all fractures, with ≤40% extraarticular (1–4). Extraarticular avulsion fractures of the calcaneal tuberosity (AFCTs) are even rarer, representing only 1.3% to 2.7% of all calcaneal fractures, with a peak incidence in females in their seventh decade (5–7). Poor bone quality, such as occurs with osteoporotic, neuropathic, and/or diabetic disease, is a risk factor (8). Different trauma mechanisms have been described, ranging from minor trauma such as tripping to strong concentric muscular contraction of the gastrocnemius–soleus complex with or without direct impact injury to the heel or calf muscle (5). AFTCs were classified by Beavis et al (1) into 3 types and in a modified classification by Lee et al (5) into 4 types. Different treatment options have been described according to the fracture type. Open reduction and internal fixation with lag screws, followed by partial weightbearing, has been the most widely accepted treatment, especially for type II fractures ("beak" fractures) (5,9,10).

We present a case of failed open reduction and internal fixation of a "beak fracture" and a review of the published data.

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Case Report

A healthy 74-year-old female was admitted to the emergency department after a contusion of the left calf while the foot was fixed to the ground and the knee was slightly bent, with subsequent severe pain at the left heel. Swelling and a hematoma with local tenderness was present around the left heel. The radiograph demonstrated a displaced avulsion fracture of the calcaneal tuberosity, a so-called beak fracture (Fig. 1). To minimize soft tissue compromise, immediate open reduction and internal fixation was performed. Preliminary anatomic reduction of the large and solid avulsed bone fragment was achieved using a pointed reduction forceps. Neither the preoperative radiograph nor the intraoperative examination showed any evidence of additional fractures of the main or the avulsed bone fragment. Therefore, 2 Kirschner wires were placed perpendicular to the fracture under observation using the image intensifiers. By overdrilling the Kirchner wires, two 3.5-mm cannulated cortical lag screws with washers were placed, which achieved very good interfragmentary compression. Although the avulsed bone fragment was solid and large enough for screw fixation according to the AO recommendations for treatment of extreme tongue-type (beak) fractures, washers were also used, assuming the presence of reduced bone quality, considering the patient's age and underlying low-energy trauma mechanism. Postoperatively, the left leg was placed in a VACO®ped boot (OPED, Cham, Switzerland) in 30° of plantarflexion. The radiograph on the first postoperative day showed anatomic reduction with a good position of the

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Fig. 1. Radiograph of the left ankle, lateral view, showing a type II avulsion fracture of the calcaneal tuberosity (“beak fracture”).

hardware (Fig. 2). However, without further trauma, the patient complained of progressive pain at the left heel on day 3. The radiograph and subsequent computed tomography scan showed a secondary displaced, shattered multifragment fracture of the calcaneal tuberosity, with the two 3.5-mm cannulated screws with washers still in place (Fig. 3). During revision surgery, the screws were removed, and the AFCT was fixed again with transosseous fixation using 2 suture anchors (3.0-mm Bio Suture Tak®; Arthrex Swiss, Belp-Bern, Switzerland) with a double Krackow suture (locking-loop) weave technique, with anatomic reduction again achieved. Furthermore, the largest fracture fragment was fixed with a single 3.5-mm cortical screw (Fig. 4). Postoperatively the left leg was again placed in a VACO®ped boot (OPED) in 30° of plantarflexion with partial weightbearing allowed for 6 weeks. At 12 weeks postoperatively, the patient had no complaints of any pain and showed a normal gait. The radiograph at that examination demonstrated a healed fracture. At 16 months postoperatively, the patient had bilateral equal range of motion of the ankles (Fig. 5) and no problems rising onto the toes (Fig. 6), and the radiograph showed a completely healed and remodeled calcaneus (Fig. 7). At that visit, the clinical rating system score for the ankle and hindfoot was 100 and the Foot and Ankle Disability Index score was 97.1. We measured our patient’s general health status using the EQ-5D-5L (5 dimensions; 5 levels). She reported no problems in walking, washing or dressing herself or performing her usual activities, no pain, and she was not anxious. She rated her general health status as 100 on a scale from 0 (worst) to 100 (best).

Discussion

The calcaneus is the largest bone of the foot and serves as the primary weightbearing structure in the heel (11). AFCTs are rare and usually present in a frail population (5,7). Hippocrates described tear

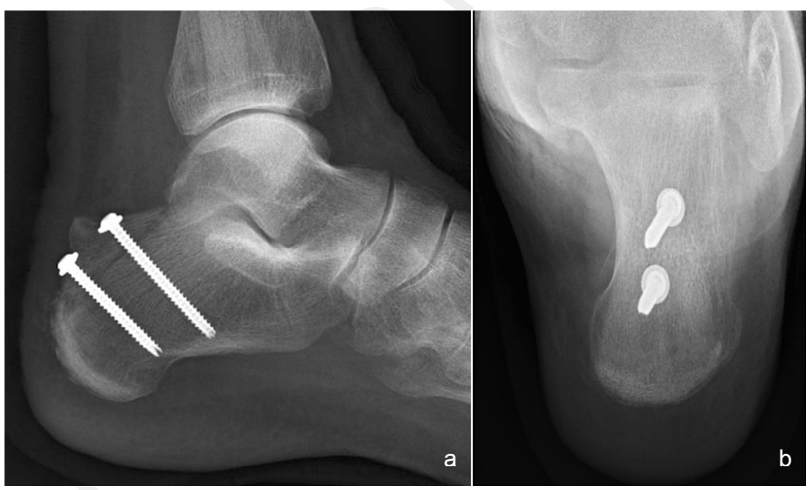

Fig. 2. Radiographs of the left ankle showing *(A)* lateral and *(B)* axial views on the first postoperative day.

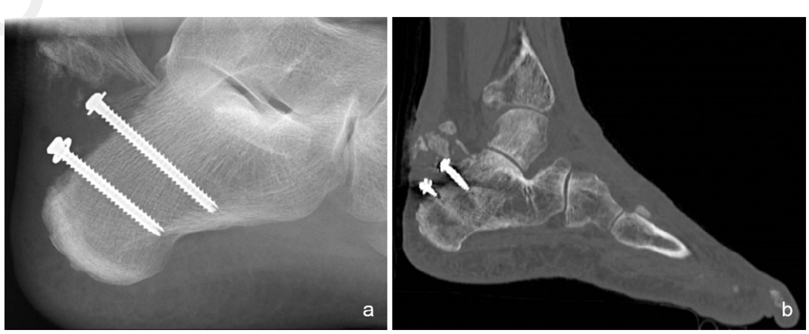

Fig. 3. *(A)* Radiograph of the left ankle, lateral view, and *(B)* computed tomography scan of the left ankle on the third postoperative day.

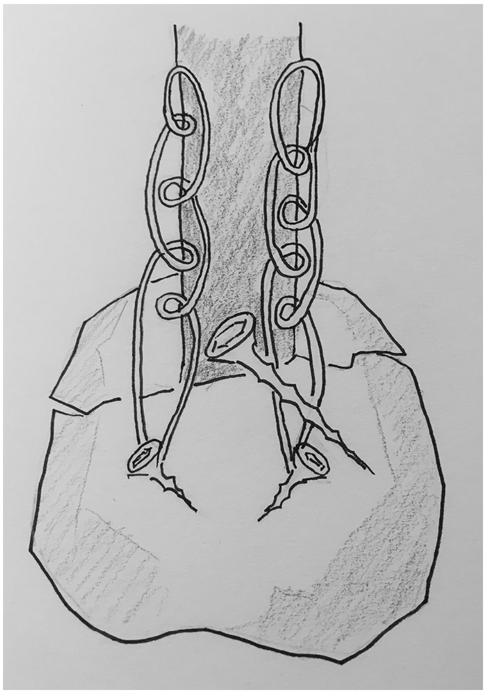

Fig. 4. Schematic drawing of the second operation.

fractures of the calcaneal tuberosity with lethal outcomes if improperly treated (3,12). The findings from the present case show that lag screw fixation might not be enough for "beak" fractures, even if the bony fragments are of sufficient size, and can result in treatment failure and reoperation.

The anatomy and forces acting at the calcaneus need to be reviewed to understand the reason for this treatment failure. The Achilles tendon (AT) is the strongest tendon in the body, with an average length of about 15 cm from the junction of the triceps surae muscle group to its insertion on the calcaneus (11,13). At the distal part, the surface of the AT is anteriorly concave and posteriorly convex, tapering to its enthesis at the middle third of the calcaneal tuberosity (11). The width of the AT at its insertion at the posterior surface of the calcaneal tuberosity varies from 1.2 to 2.5 cm (13) and covers a variable portion of the posterior surface of the calcaneus. These anatomic variations were reported by Lowy (14), who subdivided them into 2 groups: group A, with "normal" insertion of the AT at the middle third of the posterior surface distal to the posterosuperior calcaneal tuberosity; and group B, with extensive insertion of the AT to the posterior surface of the calcaneal tuberosity. Before the tendon inserts at the calcaneus, its braided and coiled collagen fibers accomplish a 90° spiral (5,13,15). With these anatomic prerequisites, the AT resists tensile strength forces of about 250% of the body weight at the end of the stand phase during normal walking or 6 to 12.5 times the body weight during running (13,15) and 489 to 661 N while riding a bicycle (16). AFCTs arise as a result of an avulsion force in which the AT plays a key role (8). Beavis et al (1) classified AFTCs into 3 types. Type I is a "sleeve" fracture in which a variably sized shell of cortical bone is avulsed from the posterior tuberosity. Type II is the so-called beak fracture, with an oblique or horizontal fracture line running posteriorly just behind Bohler's angle. Finally, type III is an infrabursal avulsed fracture by the superficial fibers from the middle third of the posterior tuberosity (1,5,11). Lee et al (5) modified this classification by adding a type IV fracture, defined as a beak fracture with a small triangular fragment avulsed from the deep fibers of the tendon only from

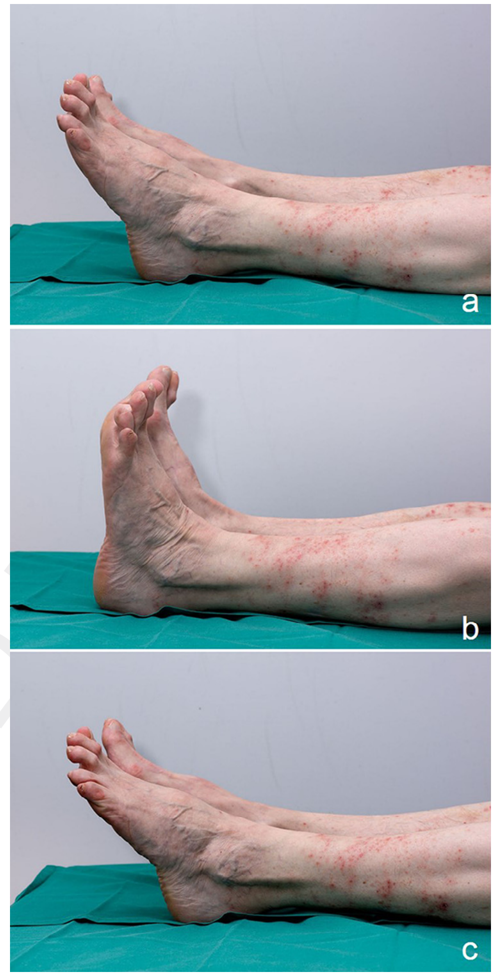

Fig. 5. Photographs showing bilateral equal range of motion of the ankles 16 months postoperatively: *(A)* physiologic, neutral position; *(B)* maximum dorsal extension; and *(C)* maximum ~~plantarflexion.~~

the upper border of the tuberosity. Lee et al (5) assigned a typical trauma mechanism to each fracture type. Type I is an insufficiency fracture mainly resulting from minor trauma such as tripping (5,11). Type III and IV fractures are mainly the consequence of more severe trauma

Fig. 6. Photograph showing equal rising onto the toes without problems bilaterally.

Fig. 7. Radiographs of the left ankle showing *(A)* lateral and *(B)* axial views 16 months postoperatively.

with a strong concentric muscular contraction of the gastrocnemius–soleus complex with the heel fixed to the ground. These fractures are mainly seen in younger patients and occur only in patients with a broad and extensive tendon insertion, according to the categorization by Lowy (5,11,14). A type II fracture, such as occurred in our patient, results from a combination of a strong concentric muscular contraction force and a direct impact injury (5,11).

Conservative and surgical treatment options have been described. Conservative treatment of an AFCT (immobilization in the equinus position) is recommended only for minimally (<1 cm) displaced fractures in which the soft tissue of the heel is not at risk and for patients with permanent impaired function present before the injury (6,17,18). Because nonoperative treatment requires immobilization for ≥6 to 8 weeks, with all the accompanying side effects and because of the possible complications such as secondary displacement, skin necrosis, and loss of plantarflexion strength (1,14,18), this treatment option should remain the exception. A displaced AFCT requires open reduction and internal fixation to restore the function of the gastrocnemius–soleus complex and prevent secondary soft tissue impairment (6,8,9,18,19). Numerous fixation options have been described, including the use of Steinmann pins and cerclage wires (20), tension-band wires (21), sole lag screws, lag screws combined with plates (21), and a wide range and variety of suture anchor fixation (6,9,10,22–26). The most widely accepted treatment option for type I and type II AFCTs has been the use of lag screw fixation (5,8,10,17). However, the findings from the present case have demonstrated that lag screw fixation might not be the best treatment option for type II AFCTs, even with bony fragments of sufficient size, and could result in treatment failure, especially in patients with decreased bone quality. Khazen et al (8) reported in their cadaveric study that lag screw fixation alone was able to resist a mean tensile strength of 251 N until failure occurred. Considering the previously stated physiologic tensile strength forces that the AT must resist (16) (e.g., 489 to 661 N while riding a bicycle) and the key role of the AT in the development of AFCTs, it seems clear that sole lag screw fixation will be too weak to neutralize the pull out force of the AT, especially in patients with decreased bone strength. Khazen et al (8) corroborated the advantage of supplementing lag screw fixation with suture anchors, which almost double the strength of the fixation. Several studies have suggested different suture techniques (6,9,10,22,23,27). We have preferred the double Krackow suture weave technique combined with only a single 3.5-mm screw for repeat fixation. Khazen et al (8) could not demonstrate a significant correlation between bone mineral density and the load to failure. They referred to the wide variation in the load to failure in their study and the small number of specimens used (8). Wren et al (28) found significantly lower calcaneal bone mineral density in the specimens that failed by avulsion rather than by AT rupture in their cadaveric study and demonstrated a significant linear relationship for AFCTs between the load to failure and bone mineral density squared.

Commonly reported issues in the treatment of AFCTs include wound healing problems and infections (especially in type II AFCTs with delayed treatment), device or treatment failure with loss of fixation, nonunion, and malunion (5,10,18). AFCTs with a neuropathic background have shown a distinctly greater incidence of these adverse events (17,18).

In conclusion, because most patients with an AFCT will have reduced bone mineral density, treatment with open reduction and internal fixation must ensure mechanical stability and effective resistance to the pull out force of the gastrocnemius–soleus complex to prevent treatment failure. Therefore, the key to successful treatment of AFCTs in the presence of reduced bone mineral density, especially for type I and type II fractures, is the neutralization of the pull out force of the AT through transosseous suture anchor fixation combined with lag screws, depending on the size of the fragments.

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